Collaboratories

In 1989, William Wulf (now president of the National Academy of Engineering but then at the National Science Foundation) coined the term "collaboratory" to describe the concept of using information technologies to make geographically separate research units function as a single laboratory. Wulf defined a "collaboratory" as a "...'center without walls' in which the nation's researchers can perform their research without regard to geographical location—interacting with colleagues, accessing instrumentation, sharing data and computational resources, and accessing information in digital libraries" (CSTB 1993).

In subsequent years, a number of programs began to develop tools for collaboratories and fund pilot projects. Among the earliest projects were:

- The NSF-sponsored Upper Atmosphere Research Collaboratory (UARC)—now the Space Physics and Aeronomy Research Collaboratory (SPARC)—which allows space physics researchers around the world to control and gather data from more than a dozen instruments located around and above the globe. SPARC is based at University of Michigan (<<http://www.crew.umich.edu/UARC/>>); it has collaborators from many institutions.
- The DOE-sponsored Materials MicroCharacterization Collaboratory (<<http://tpm.amc.anl.gov/MMC>>), which conducts research on the microstructure of advanced materials. This effort involves three DOE national laboratories, the National Institute for Standards and Technology (NIST), the University of Illinois, and several scientific instrument companies.
- The DOE-sponsored Diesel Combustion Collaboratory (<<http://www.collab.ca.sandia.gov/Diesel/ui/>>), which focuses on diesel engine emissions control and involves three DOE national laboratories, the University of Wisconsin, and several diesel engine manufacturers.

These collaboratories use a similar set of technologies for collaboration, including:

- Internet-based desktop video conferencing;
- Shared access to databases and computer simulation;
- Shared virtual workspaces, such as "white boards" on which researchers can sketch out ideas; and
- Shared electronic laboratory notebooks to capture the details of experiments.

One of the most important aspects of collaboratories is the ability to share scientific instruments over the Internet. This sharing may involve many users from different sites using a single major scientific instrument, such as a synchrotron at a national laboratory, or it may involve using a network of instruments, such as environmental sensors in geographically separate parts of the globe.

Many of the tools developed in these and other pilot projects are now being used in other research collaborations.*

Among the benefits of collaboratories (Ross-Flanigan 1998) are that:

- Scientists can avoid going to scientific instruments in remote locations.
- Many more universities, scientists, and students can participate in or observe experiments.
- By connecting computation to experiments, scientists can better and more quickly integrate experiments and theory. Theorists and experimentalists can work together in real time, greatly reducing the time required to analyze experiments.
- Scientists can put together quick video conferences to discuss the data.
- Students can participate in experimentation much earlier in their careers than before.

On the other hand, virtual communication has been found to be less successful than face-to-face communication in building trust between researchers. In addition, as a result of greater outside participation in the research, good researchers have more distractions. The early collaboratories also found that Internet congestion, the lack of reliability of some of the tools, and software changes slowed research.

*See, for example, <<http://www.si.umich.edu/research/projects.htm#collabor>>; <<http://www.mcs.anl.gov/DOE2000/pilot.html>>; <<http://doe2k.lbl.gov/doe2k/index.html>>.

IT and the Citizen

IT in the Home

The breadth of information technologies in the home is considerable, ranging from televisions and telephones to smart house technology, microprocessors in coffeepots, personal computers (PCs), and the Internet.[8] The trends and developments presented here focus only on home computers and Internet linkages,[9] not on the full spectrum of home informatics or ways in which people can access the Internet outside of the office (such as in libraries, kiosks, or Internet cafes). In addition, the analysis concentrates on social impacts that occur within the home itself, such as changes in individuals, in family dynamics, or in household operations.

[8]For a more extensive discussion of the diffusion and effects of information technologies in the home, see National Science Foundation, *The Applications and Implications of Information Technologies for the Home* (1999) (available at <<http://srsweb.nsf.gov/it_site/index.htm>>); National Technical Information Administration, *Falling Through the Net: Defining the Digital Divide* (1999) (available at <<http://www.ntia.doc.gov/ntiahome/digitaldivide/>>).

[9]Note that there is increasing diversity in technical access to the Internet—for example, through television (web TV™) and telephones. Such alternative mechanisms are not explicitly addressed in this study; most research reviewed here assumes that Internet access is achieved through a personal computer.

The broader social impacts of home-based computing—for example, on culture and values, democratic participation, and social cohesion—are not addressed; neither are the impacts of home-based businesses that are facilitated by PCs and Internet linkages.

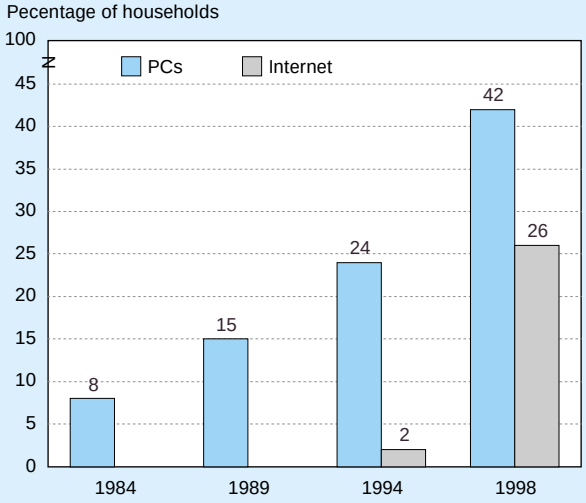
Two distinct eras characterize the diffusion of home computing in the United States. The first era is reflected in the steady growth in home ownership of personal computers throughout the 1980s (PCs were introduced commercially in the late 1970s); the second era is reflected in the accelerating adoption of home PCs and Internet use that began about five years ago. As the cost of home computers dropped to less than $1,000 and as Internet service providers shifted to flat-rate pricing, the rate of home PC diffusion and Internet access began to increase. In 1998, more than 42 percent of American homes had at least one personal computer, and 26 percent of American homes were connected to the Internet (NTIA 1999).

The growing access to home computing has not been evenly distributed, however. People with less than a high school education have less access to computers than people who have completed high school and much less than people who have completed college. (See "Use of Computers and Computer Technology in the United States" in chapter 8, figure 8-19, appendix tables 8-29 and 8-30.) Moreover, the National Telecommunications and Information Administration (NTIA) has repeatedly identified a "digital divide" in the United States, which it defined as a home computing gap between white or affluent Americans and those who are ethnic minorities or poor (NTIA 1995, 1998, 1999). Although disadvantaged groups have substantially increased their home access to computers and the Internet, the gap between these groups and white Americans is growing—at least temporarily.

Trends in PC and Internet Access

Personal computers were commercially introduced in the late 1970s, and home Internet access became widely available to the general public around 1992–93. The earliest reliable data on PCs in the home are from 1984; for Internet access, the earliest data are from 1994.[10] (See figure 9-23.) Rapid growth in home ownership of personal computers has occurred principally since 1994. During the four-year interval from 1994 to 1998, the percentage of households owning a home computer increased by 18 percentage points—double the 9 percentage point increase for the five-year period from 1989 to 1994 and far greater than the 7 percentage point growth from 1984 to 1989. Internet access has expanded phenomenally; the number of households connected to the Internet has grown from 2 percent of all households in 1994 to 26 percent in 1998.

Figure 9-23.
Percentage of U.S. households owning a home computer and percentage of U.S. households with access to the Internet



SOURCES: U.S. Census Bureau, except for 1994 data, which is from Clemente (1998).

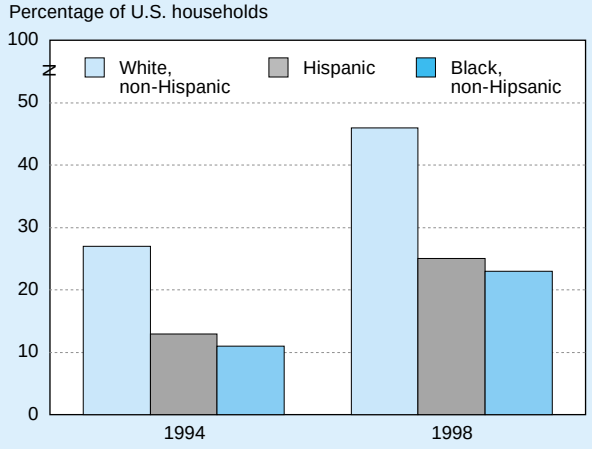
Science & Engineering Indicators – 2000

Inequities in Access. The recent rapid growth in home adoption of IT masks considerable disparities in access to IT by income levels, ethnic affiliation, and geographic location. Using data from the Current Population Survey conducted by the Census Bureau, the NTIA found that the "digital divide" is worsening among Americans (NTIA 1995, 1998, 1999). From 1994 to 1998, the gap in PC ownership between white and black or Hispanic households widened, as did the gap between rich and poor. Although ownership of home computers and Internet access increased in all income and ethnic categories during these five years, the disparity in ownership has widened. For example, in 1998, 46.6 percent of white Americans owned a home computer, compared to 23.2 percent of black Americans—a gap that increased by nearly 7 percentage points from 1994 (NTIA 1999). (See figure 9-24.) Notably, PC ownership is greatest for households with residents of Asian/Pacific Island heritage—55 percent of such homes own a PC.

Affluence alone does not account for these differences: Within every income category, blacks lag whites substantially in adopting home computers and linking to the Internet, although the gap is not as large at higher income levels. The NTIA reports that "the role of race or ethnic origin is highlighted when looking at similarly situated families. A white, two-parent household earning less than $35,000 is nearly three times as likely to have Internet access as a comparable black household and nearly four times as likely to have Internet access as a Hispanic household in the same income category" (NTIA 1999). Geographic location has an impact on household PC ownership and Internet access beyond that predicted

[10]Note that data on Internet access for households do not necessarily reflect constant subscription to the Internet. Households can sign up for the Internet and then drop or even switch Internet service providers (a process known as "churn"). As a consequence, survey data reflect "snapshots" of households connected to the Internet at the point in time at which the survey was administered.

Figure 9-24.
U.S. household ownership of personal computers, by race/ethnicity: 1994 and 1998



SOURCE: NTIA (1999). *Science & Engineering Indicators – 2000*

by income levels; households in rural areas are less likely to own PCs or be connected to the Internet even when income is held constant in statistical analyses (NTIA 1999). Certain groups thus appear to show consistently low levels of home IT access—particularly households that are low-income; persons who are black, Hispanic, or American Indian; less-educated Americans; single-female headed households; and households located in the South, in rural areas, or in central cities.

Determinants of Home IT Adoption. The research literature on technological diffusion shows that there is a distinctive socioeconomic (income, education, occupation) "early adoption" bias by individuals who are affluent, more highly educated, and from higher-status occupations compared to society as a whole.[11] This pattern holds across all kinds of household products, technologies, and innovations, and personal computers and Internet access are no exception.

Research conducted in the 1980s on home PC diffusion found that income and other socioeconomic factors were strong predictors of early PC adoption (Dickerson and Gentry 1983, McQuarrie 1989, Riccobono 1986); in a major review of the literature from 1980–87 on home IT diffusion and impacts, Dutton, Rogers, and Jun (1987) found that level of formal education was the "single variable most consistently associated with the adoption of computing." Research on the new wave of Internet access confirms the same trend in early PC adoption. The NTIA (1995, 1998, 1999) studies discussed above, as well as Clemente's (1998) findings on Internet households, substantiate the significant influence of income, education, and occupation on home Internet use.

Demographic variables do appear to play a role in home IT adoption behaviors. For example, Hoffman and Novak (1998) found complex relationships among home IT access, race, income, and levels of education. In their study, gaps in home IT access emerged for which neither level of income nor education could account. Hoffman and Novak found that differences in levels of home computer ownership between blacks and whites were statistically significant after controlling for level of education. In addition, Hoffman and Novak found that income could not account for extreme disparities between white and black students with respect to computer ownership: 73 percent of white high school and college students owned a home computer, whereas 33 percent of black students owned a home computer. The NTIA studies also identify persistent differences between whites, blacks, and Hispanics that level of income and education cannot explain.

Research suggests that a few other factors are important influences on IT adoption dynamics. Family structure (marital status of head of household, presence of children in the household, age of the head of household), for example, emerged in several studies as a differentiating factor for home PC and/or Internet access (Caron, Giroux, and Douzou 1989; Clemente 1998; Dutton, Rogers, and Jun 1987; NTIA 1998). In general, families with children and married parents are more likely to have personal computers or link to the Internet than single people, couples without children, single heads of household, or households headed by very young adults. (Note that income could be an intervening factor for these latter two family structures.) In addition, individuals with a positive attitude toward technology or computers are more inclined to adopt personal computers (Dickerson and Gentry 1983; Dutton, Rogers, and Jun 1987).

Patterns of Home IT Use

Research and data on patterns of IT usage fall into two distinct categories: research conducted in the mid-1980s on the use of home computers and research conducted in the mid-1990s on Internet use. Thus, there is a substantial gap in our understanding of how computers are used in the home. Not only do the studies on PCs essentially reflect early users—a group of people who are known to be atypical of the general population—but they tend to be studies that, because of their research design, cannot be generalized to the overall population. In addition, the software and user interfaces that we have today were designed primarily by and for white men, leading to more subtle psycho-cultural influences on adoption patterns (CSTB 1997). As a consequence, the findings for PC use should be regarded as suggestive (certainly not definitive): They identify areas of potential research interest and analytical need.

Home Use of PCs. Early adopters of home computers did not necessarily use their machines intensively. For example, Riccobono (1986) found that in a typical week, 40 percent of adults did not use their computer at all. In general, many households found that they were using the PC less than expected, and in Riccobono's national study, 43 percent of adult computer owners indicated that they used their computers much less than they expected at the time of purchase. These find-

[11] "Early adopters" are individuals who purchase and use new technologies when they are introduced to the marketplace. See Dickerson and Gentry (1983) and McQuarrie (1989) for treatments of the literature on early adopter patterns in households.

ings are consistent with other "underutilization" findings reported in Caron, Giroux, and Douzou (1989); Dutton, Rogers, and Jun (1987); and Giacquinta, Bauer, and Levin (1993).

These patterns of use were variable across family members, however. In the Riccobono study, only 16–20 percent of children in the home ages 6–17 did not use the computer at all in a typical week, compared to 40 percent of the adults. Although 45 percent of the parents were non-users in the Giacquinta, Bauer, and Levin study, only 16 percent of the children were non-users. Fathers tended to dominate use of the computer in the home (Caron, Giroux, and Douzou 1989; Giacquinta, Bauer, and Levin 1993), and females tended to represent a higher proportion of non-users across all age groups (Giacquinta, Bauer, and Levin 1993, Riccobono 1986).

Evidence regarding the dominant content of PC use (for example, word processing, education, games, and so on) is mixed, and the research cannot be systematically summarized because of limited data, vastly different research designs, and different ways of presenting questions to survey respondents. The one theme that consistently emerges is the major role of education in early-adopter PC use; the importance of educational uses of the computer tends to be cited more often and in higher proportions by most studies than any other type of application (Dutton, Rogers, and Jun 1987, OECD 1998). Other salient uses appeared to be games, word processing, and work-related tasks, as well as programming and learning about the computer itself (Caron, Giroux, and Douzou 1989; Dutton, Rogers, and Jun 1987; Giacquinta, Bauer, and Levin 1993; OECD 1998; Riccobono 1985).

Home Use of the Internet. E-mail and World Wide Web (WWW) activity dominate home Internet use; in general, e-mail appears to be the more important activity. Kraut, Mukhopadhyay, et al. (1998) find from computer records that people use e-mail more frequently than the WWW and will use e-mail first in online sessions that include both e-mail and WWW activity. Indeed, people who used e-mail more than the WWW were more likely to continue using the Internet over the course of a year than people making greater use of the Web. Census data indicate that e-mail is used overwhelmingly to communicate with family and friends: More than 90 percent of all users report using e-mail at home for this type of communication, compared to only 33 percent (or less) who report using e-mail for work, hobbies, or educational activities (NTIA 1999).

Use of the Web is both idiosyncratic and generalizeable. For example, Kraut et al. (1996) find that the Web sites visited by family members in their study were unique to the individual. Of the roughly 10,000 unique addresses visited during the study, 55 percent were accessed by only one person, and less than 2 percent were visited by 20 percent or more of the individuals in the sample (these sites tended to be search engines and Web portals).

Usage is nonetheless patterned by broad categories. For example, in terms of general information searches, the American Internet User Survey reveals that health and medicine are the most popular Internet subjects. Thirty-six percent of all users and 47 percent of women report exploring this subject; other major areas of interest include entertainment, music, parenting/children, and lifestyles subjects.[12] NTIA (1999) finds distinctive patterns of Internet use in terms of the purpose for using the Internet at home. In general, individuals with higher income and higher education levels are far more likely to use the Internet for work-related activity, whereas minorities and unemployed individuals are enthusiastic users of the Internet for employment searches and taking educational courses.

Research and Findings on Effects of IT on the Home

Three categories of impact research are addressed here: time displacement studies, the impacts of teleworking on the home, and psychological well-being. The limited research on the impacts of IT shows this technology to be a bit of a mixed blessing: Although IT has the potential to improve the quality of life of the home and the individuals within it, IT also has the potential to be abused or lead to harmful consequences.

Time Displacement Studies. Time displacement studies assess the degree to which the introduction of a new technology in a household affects patterns of time use and allocation. Such studies have been carried out with respect to vacuum cleaners, automobiles, televisions, and microwave ovens, among other technologies. Three time displacement studies have been conducted with respect to home computing. Two focus on the impacts of home computing and the Internet on use of traditional news media (newspapers, TV, radio, books, and magazines); the other explores how individuals reallocate their time once home computers are brought into the household.

Robinson, Barth, and Kohut (1997) analyzed data from the Pew Research Center for the People and the Press on IT in the home. Curious about whether use of the Internet and home computers displaces use of traditional news media, the authors analyzed 1994 and 1995 survey data that reflect when and how often individuals use different kinds of media. Although they found a variety of correlations, few were statistically significant, of meaningful magnitude, or represented a clear pattern that could not be accounted for by socioeconomic factors. In general, however, the authors found that IT use in the home was associated with an increased use of traditional news media, not a decrease. Although they conclude that IT may therefore be media enhancing, home IT users also may be generally more "news seeking" than non-IT users.

Clemente (1998) analyzed data from the American Internet User Survey conducted by Cyber Dialogue and found patterns of media displacement that tend to support the Robinson, Barth, and Kohut findings. Clemente found that about one-third of all Internet user households reported that they watched less TV, although this displacement tended to be slightly higher for recent adopters than those who had been using the Internet

[12]Data from the American Internet User Survey (<<http://www.cyberdialogue.com/free_data/index.html>>), accessed August 19, 1999.

for a year or more. The number of households that had been using the Internet for more than one year that reported declines in reading of newspapers, books, or magazines and listening to the radio ranged from 10 to 13 percent.

Vitalari, Venkatesh, and Gronhaug (1985) cast a broader eye on the time allocation impacts of home computing. In a study of 282 members of computer clubs in Orange County, California, the authors assessed the impact of computing on 10 household activities: watching TV, reading, leisure time spent with family, leisure time spent with friends, outdoor recreation, sports, hobbies, sleeping, time spent alone, and studying/doing homework. Notably, 96 percent of the respondents were men; this gender bias, as well as other factors (the majority of respondents had previous experience with computers and worked in technical professions) make this a particularly nonrepresentative group of respondents.[13] Nonetheless, the authors detected major time reallocation patterns; major shifts (e.g., more than 20 percent of the respondents reported the change) were detected with respect to decreased television watching, outdoor recreation, hobbies and sleeping, and major increases in time spent alone and studying were observed. (Note that these latter two activities are not mutually exclusive.) The greatest shifts in time allocation patterns were reported in families with children—suggesting that such households are particularly sensitive to the introduction and presence of a computer.

IT, Work, and the Home. Teleworking has long been hailed as one of the major social benefits of IT. By enabling individuals to stay home and work—whether by telecommuting to a parent office or establishing a home-based business—the relocation of work to the home is believed to offer multiple advantages to individuals and families. Flexible work hours, lower household costs, less stress from family—work conflicts, reduced commuting times, and so on are believed to be important payoffs to computer-based work at home.

The vast majority of research on teleworking addresses the economic benefits of these arrangements to parent companies. Traditional research on the impacts of telework focuses on such factors such as productivity, job satisfaction, work attitudes, job stress, overwork, and employee turnover. Little research has been conducted on teleworking in which the impact on home and family life are the focus. Habib and Cornford (1996) reviewed the research related to telework impacts on the home and identified key areas of concern: the effect on rules, norms, and roles in the household; the blurring of spatial boundaries between home and office; and the disruption of time patterns in family routines. Gurstein's (1991) research on 45 home workers echoes these concerns. Her research indicates that IT home workers express guilt over neglecting their families, discomfort with the loss of their home as a "refuge" from work, and a sense of isolation and being devalued by their office colleagues. Gurstein wonders exactly what flexibility advantages are created by telework and concludes that home-based computer work "results in role conflicts, inadequate workspaces, the blurring of the work/leisure time division, and the tendency for 'overwork' to occur" (Gurstein 1991, 177).

In contrast, Riley and McCloskey (1996) found that limited use of teleworking arrangements may have positive home impacts. Reporting on a pilot program in which GTE Corporation allowed managerial employees to work at home one day a week for six months, the authors found that "of the 120 participants in the telecommuting pilot study, 75 percent reported increased feelings of satisfaction with their home life, [and] 44 percent reported having more quality time with the family" (Riley and McCloskey 1996, 87).

[13] In addition, because this study was most likely conducted in 1984, respondents are also "early adopters" of home computers. As others have shown (e.g., Dutton, Rogers, and Jun 1987), early adopters of home computers are atypical of the general population in a variety of ways.

IT and Disabilities

Information technologies have the potential to improve the lives of people with disabilities. IT can make work from home more viable for people with limited mobility, turn written material into spoken language for visually impaired people, and turn speech into text for hearing-impaired people.

Information technologies do not automatically provide benefits to the disabled, however. Unless they are designed carefully, they can create new barriers. Web sites, for example, frequently convey information in a visual form that is inaccessible for people who are visually impaired.

The World Wide Web Consortium, a standards-setting organization for the World Wide Web, has developed guidelines to make Web sites more accessible (<<http://www.w3.org/TR/WAI-WEBCONTENT/>>). Among the guidelines are the following:

- There should be text equivalents for all nontext elements, including images, animations, audio, and video.
- There should be text summaries of graphs and charts.
- All information conveyed with color should also be available without color.
- The clearest and simplest language appropriate for a site's content should be used.

The Center for Applied Special Technology (<<http://www.cast.org>>) provides a free Web-based tool to analyze Web pages for their degree of accessibility to people with disabilities. Within the U.S. government, the Center for IT Accommodation (CITA; <<http://www.itpolicy.gsa.gov/cita/>>) in the General Services Administration's Office of Procurement Policy works to improve the accessibility of information technology.

These telework studies generally predate widespread access to the World Wide Web and major changes in distributed work arrangements in the private sector. As a consequence, they may not reflect the variety of household impacts that come from less insulated and "closed" work systems. Nonetheless, these studies are suggestive of a common theme in the theoretical and philosophical literature on IT—namely, the omnipresent duality of IT impacts. On one hand, teleworking can enhance people's ability to better balance work and family needs and reduce personal stress. On the other hand, home-based IT work can disrupt crucial family dynamics (roles, interpersonal relationships, and the sense of home as sanctuary) and create psychological isolation and low self-esteem. The extremely limited research described here suggests that there may be threshold effects associated with telework: The degree and intensity of telework's presence in the home may be damaging rather than telework per se.

Psychological Well-Being. As with so many other potential impacts of IT in the home, the influence of computing on the psychological well-being of individuals can be beneficial or harmful. Greater connectedness to a community, ease of communication with family and friends, and improved access to information can enhance self worth, feelings of satisfaction, a sense of community and kinship, and personal empowerment. Scholars express equal concern, however, for the dark side of computing: isolation; growing social insularity; and increasingly, "Internet addiction." A body of psycho-behavioral work exists with respect to computer-human interactions and computer-mediated communication; three empirical studies stand out, however, with respect to the psycho-behavioral impacts of Internet use. These studies relate to Internet addiction, social integration, and loneliness and depression.

Although the existence of Internet addiction as a clinical disorder remains in dispute, some professionals unequivocally assert that it is a real phenomenon.[14] Egger and Rauterberg (1996) explored whether heavy use of the Internet reflects addictive behavior; data were obtained from an online survey posted and advertised on the World Wide Web. Roughly 450 valid survey responses were received, largely from Swiss and American respondents.[15] Although the findings of the survey cannot be generalized outside the sample, the key findings are suggestive for future research. First, 10 percent of respondents perceived themselves as addicted to or dependent on the Internet, and objective measures of addiction, on the whole, were statistically significant for this group. Second, this small group of "Internet addicts" represented all walks of life. There were no statistically significant demographic differences between people who were considered Internet addicts and those who were not—this group was not differentiable by gender, age, nationality, or living situation.

Concerns that Internet users may be socially withdrawn from their communities are not substantiated in research reported by Katz and Aspden (1997). They found that after controlling for demographic differences between groups (age, gender, education, race, and income), there were no statistically significant differences in the degree to which Internet users were members of religious, leisure, or community organizations compared to non-users. In addition, Katz and Aspden found that the vast majority of Internet users (whether recent or long-term) reported no change in the amount of time spent with family and friends on the phone or through face-to-face contact. Interestingly, the data indicate that long-term Internet users belong to more community organizations than any other group (non-users, former users, and so forth).

In contrast, Kraut, Lundmark, et al. (1998) found evidence that greater use of the Internet was associated not only with increased social disconnectedness but with loneliness and depression as well. Using data from the HomeNet study, the authors found that greater use of the Internet was associated with "small but statistically significant declines" in social integration as reflected by family communication and the size of the individual's social network, self-reported loneliness, and increased depression. These correlations held even after the authors controlled for initial states of loneliness, social involvement, Internet use, depression, stress, and so forth. Although the authors' claim that their methods and findings indicate a causal relationship between increased Internet usage, declining social involvement, and worsening psychological states is an overstatement, the findings nonetheless show important statistical associations.[16]

IT at Home: Summary

Twenty years after the advent of the personal computer, we have a relatively clear picture of who has access to home computers and, more recently, the Internet. Patterns of IT diffusion and adoption clearly suggest that IT is still a resource acquired to a greater extent by more affluent and well-educated Americans. Although PCs have been diffusing rapidly in recent years, they have yet to make substantial inroads into poor and minority households, and research on PC and Internet adoption behaviors indicates that socioeconomic and demographic factors continue to be the primary predictors of home IT access. Very simply, income allows families to hurdle affordability barriers to adoption, and well-educated individuals are more likely to be aware of and appreciate the ways IT can be used in the home.

The picture is less clear with respect to usage patterns. The early adoption research suggests that the primary uses of home computing are for education, play, work, and basic word processing; findings generally suggest that children tend to use home PCs more often and for longer periods than adults. Sizeable proportions of early adopters found that they used the computer less than they initially expected.

[14]See, for example, Kimberly S. Young, *Caught in the Net* (NY: John Wiley and Sons, 1998).

[15]The authors were from Switzerland, so most of the respondents were Swiss. The survey was posted in English and German, however.

[16]The models do not account for environmental conditions known to trigger social withdrawal and depression (such as loss of a job or marital conflict). Thus, they do not allow for intervening environmental variables or the possibility that greater Internet use could be a consequence of depression, loneliness, and social withdrawal caused by other factors.

Recent research on Internet use reinforces some of the impressions generated by the early computing studies: Children and male teenagers still tend to be the heaviest users of IT. The Internet has made a new form of interpersonal communication available to households, and several analyses suggest that e-mail and personal communication drive Internet use by individuals and households. Specific informational content derived from the World Wide Web is unique to each individual's interests and needs, although broad patterns of information use are emerging. Americans most often seek information related to health and leisure; affluent and educated individuals also use the Internet for work, whereas socioeconomically disadvantaged groups use the Internet to seek jobs and to take classes.

What we do not know about impacts is substantial. How do families and individuals use information gained from the World Wide Web, and with what consequence? What are the outcomes of the growing role of e-mail in some families' lives? Are families with e-mail any better off than families without e-mail? How does the presence of home computing affect family dynamics and relationships? Does it diminish or enhance quality of life, and under what circumstances? Are there pathologies associated with extensive Internet use? How does computer-based work at home affect the nature of the home itself?

Least understood is whether the socioeconomic inequities that exist in access to home information technologies matter, and how. The implicit assumption is that the absence of IT in the home perpetuates social and economic disadvantages. Childers (1975) creates a vivid portrait of how minorities, the underclass, and other groups in the United States tend to have fewer lines of access to information and less effective information networks than the rest of society. On the other hand, if the effects of computers on the home are mixed, the lack of home computers may not be as critical.

Information Technology, Government, and Citizens

Like businesses, government agencies have used IT in management information systems and in research for decades. With the advent of the Internet and especially the World Wide Web, however, IT has become a major means of communicating with citizens and stakeholders.

IT influences government in a variety of ways. The Internet is a very effective way to disseminate government-related information. Government agencies are placing information about their policies and programs, as well as information that they have developed or supported, on the Web. Examples of U.S. government information resources include STAT-USA (<<http://www.stat-usa.gov>>)—a service of the U.S. Department of Commerce that provides business, economic and trade related Federal Government information—and NSF's science statistics (<<http://www.nsf.gov/sbe/srs/stats.htm>>), including this volume. The National Technical Information Service (NTIS), which has been the distribution channel for government-sponsored technical reports, recently decided to close because agencies are offering their publications directly to the public over the Internet (for no charge). States and local governments are also using the Web to make information readily available to the public.

The Internet is also affecting political processes in the U.S. and around the world. Political candidates are establishing Web sites to communicate with voters, solicit funds, and organize volunteers. Interest groups are using e-mail and Web sites to organize and express their views. In some cases, groups that would be very difficult to organize through traditional means—such as scientists or engineers in different parts of the country—can be mobilized through e-mail to express their views to the Congress on a timely issue. Other groups are experimenting with Internet voting. For example, the U.S. military is exploring using the Internet to provide a new mode of absentee voting for its overseas personnel.

Overseas, the Internet is providing a way around government controls on information. If a country allows its citizens to have access to the Internet, it is very difficult to prevent them from using it to gain access to information. For example, although China controls Internet service providers and blocks access to many Web sites, overseas Chinese send news via e-mail to large numbers of e-mail addresses, obtained from public lists, in China (Plafker 1998). The people who receive the e-mail can honestly tell authorities that they did not request the information.

As in the United States, governments around the world are using the World Wide Web to communicate with their constituencies. The Cyberspace Policy Research Group at the University of Arizona analyzes worldwide government use of the Web. Group members scan the Web for new agency sites, record the URLs, and analyze Web operations according to indices of transparency, interactivity, and openness. (See figure 9-25.)

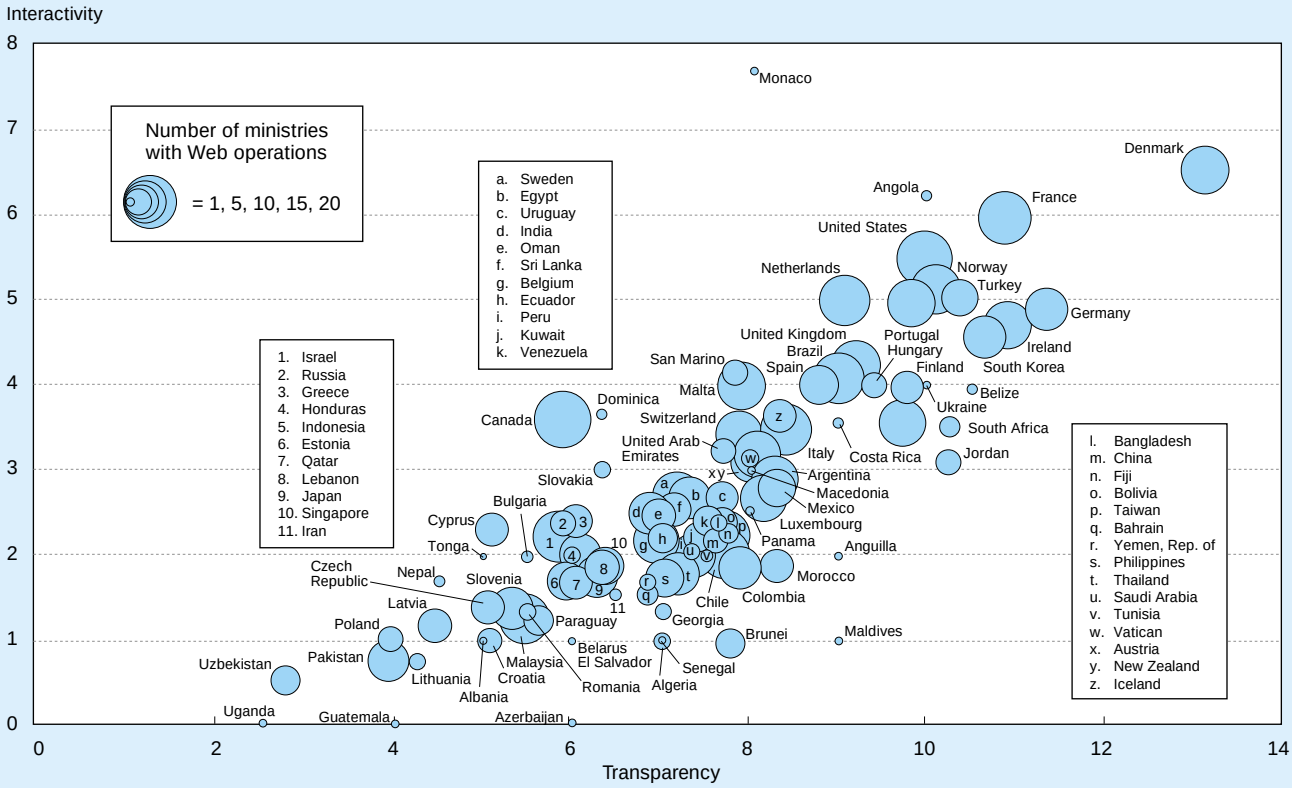
The transparency index measures the information an agency provides about itself and is based on measures of:

- how involved the agency is with the site;
- how easily the Web site visitor can contact people in the organization;
- how well information is provided about an organization's operations and relationships with other organizations;
- the extent to which the Web site helps citizens comply with regulations or take advantage of government programs, such as by making forms available; and
- how current an agency's information is.

The interactivity index measures the convenience with which information can be accessed. If information is theoretically available but practically difficult to obtain, the organization scores poorly on interactivity.

The size of each bubble in figure 9-25 indicates the number of top-level government agencies with Web sites for that country. The vertical axis shows the country's rating on interactivity, and the horizontal axis shows its rating on transparency. Countries in the upper right quadrants can be consid-

Figure 9-25.
Openness and its components: transparency, interactivity, and number of ministries



See appendix table 9-9.

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ered to use the Web to enhance the openness of government to a greater extent than countries in the lower left quadrant. A large number of national governments use the Web extensively. Almost 40 countries had Web sites for 70 percent or more of their agencies in 1998, and 17 countries had Web sites for all of their top-level agencies. (See appendix table 9-9.) There is also substantial variation in the measured transparency and interactivity of the countries, suggesting that countries vary in the extent to which they are currently taking advantage of the Web to interact with their citizens.

Conclusion

IT is having substantial effects on many domains of society, including the economy, education, research, and the home. In most areas, however, the effects of IT—and the choices that can be made to influence the effects—are not well understood. Moreover, significant new technologies are changing the nature of the effects as they are being researched. There is a large agenda for future research.

NSF sponsored a National Research Council (NRC) study of research needed on the economic and social effects of IT (CSTB 1998). Although the NRC panel did not attempt to provide a comprehensive research agenda, it highlighted an illustrative set of promising areas for research:

- **Interdisciplinary studies of information indicators.** Interdisciplinary study could help to identify and define a set of broadly accepted measures of access to, and the use and effect of, information and IT. (See sidebar, "Potential Information Technology Indices.")
- **Effects of IT on labor market structure.** To facilitate informed decisions on issues such as how to respond to increasing wage inequality, it is important to understand how and to what extent the use of computers might affect wage distribution.
- **IT, productivity, and its relationship to work practices and organizational structures.** Much evidence suggests that IT's effect on productivity depends on how it is used in organizations. Compilation of work that has already been done in this area is needed. Continued research also could illuminate how to better quantify the economic inputs and outputs associated with use of computers.
- **Intellectual property issues.** Policymakers considering revisions to intellectual property law or international agreements, as well as firms evaluating possible approaches to protecting intellectual property, would benefit from continued theoretical and empirical research.